Report of the SNS Beam Diagnostics Advisory Committee

July 18, 2001 Linac D-Plate PDR Review

Committee members in attendance: Sasha Aleksandrov, Frank Bieniosek, Michael Borden, Tom Powers, and Bob Webber

General scope of the review as identified by Mike Plum: Evaluate the preliminary design against design requirements (specified, e.g., in the System Requirements Document and the Design Criteria Documents). Evaluate interface definitions. Evaluate high-level schedule. Comment on design decisions, the design process, and the design approach. This D-Plate PDR will not review sub-systems covered in other reviews, such as BPMs, wire scanners, current monitors, energy degrader / Faraday Cup, emittance measurement electronics, and facility-level vacuum and water.

Charge to committee

Review the Design

1. Are the design requirements adequately defined?
2. Is the D-Plate design at PDR status?
3. Are the right analyses/tests being done/planned?
4. Does the work from PDR to FDR (Winter ’01) look reasonable?
5. Are there “gaps” in the design?
6. Are the interfaces defined, understood, and addressed?

General Remarks and Comments Relevant to the Charge

The review committee was presented with plans, requirements, and designs for the Linac D-Plate assembly. The D-Plate is to be utilized to measure properties of the 7.5MeV beam from DTL Tank 1 and to permit full power operation of all systems with beam through DTL Tank 1. The presentations focused primarily on the mechanical aspects of the D-Plate since many of the diagnostics subsystems are intended to be the same as those used and reviewed elsewhere as part of the permanent SNS Linac installation.

Jim Stovall gave a convincing motivation for incorporating the D-Plate beam measurements into the Linac commissioning plan. The opportunity to characterize the low energy DTL beam will exist only prior to DTL Tank 2 installation. SNS may well be able to meet early milestones without the D-Plate system beam measurements, however ultimate machine performance might be compromised if the low energy beam is incompletely characterized. Already, emittance measurements of the RFQ output beam show unexpected and undesirable results. The D-Plate will permit full power operation for early, integrated systems testing; that opportunity will not again present itself until the complete full energy Linac, Ring, and Target systems are all in place and ready for commissioning. For these reasons, the D-Plate was conceived. The D-Plate is an expensive “one-use” assembly intended to serve just these purposes. If the project schedule fails to

include and support sufficient time to perform these beam measurements and system exercises, then considerable money and effort spent on the D-Plate shall have been wasted.

Overall, the committee perceived that the beam diagnostics capabilities of the D-Plate design are being actively and productively pursued and that the effort is on an appropriate path toward a FDR this coming winter. Several concerns are noted, but no showstoppers to preclude the D-Plate from performing at the level specified in the requirements were identified. The most important issue observed by the review committee is not with any D-Plate design detail, but with apparent lack of integration of the D-Plate into the Linac installation and commissioning schedule. The D-Plate cannot perform in isolation; considerable support must be provided in the way of power, water, and vacuum utilities as well as by the control and MPS systems. These support systems must be folded into a realistic schedule that is also consistent with 2.5MeV front-end tests. Many of the committee's comments will therefore be found directed to system issues rather than design details.

The committee believes that the D-Plate will serve an essential purpose toward satisfying final SNS project milestones and that it is important to expend the significant effort that will be required to exploit the D-Plate potential. The machine and shielding configuration required to operate DTL 1 and D-Plate concurrently with downstream installation should be explored.

The committee appreciates correction where our observations may be off the mark and offers suggestions, not criticisms, as hopefully constructive ideas or approaches toward a successful and on schedule suite of beam diagnostics for SNS.

Committee Observations and Recommendations

Committee Observation – Stovall's presentation provided an excellent **motivation** and outline for exploiting the D-Plate.

Recommendation – The outline Jim provided should be **fleshed out**, quantified, and detailed with a commensurate schedule to justify making time for the D-Plate in the commissioning scenario and to serve as realistic input to establish an integrated schedule for Linac commissioning.

Committee Observation –**Systems integration and interface** issues abound with the D-Plate: mechanical, survey, machine protection system, controls system, software, physical plant and supporting utilities, radiation safety, personnel safety, shipping, and schedule. The D-Plate is the odd man out. It has enough similarities to other parts of the linac that it is easily taken for granted, but is sufficiently different to deserve special attention. If the D-Plate is to provide benefit to the project, it uniqueness and special needs must be attended.

Recommendation – **Management** should focus on these systems issues to assure that the D-Plate engineering requirements and specifications are appropriate and that the D-Plate will be sufficiently exploited. The D-Plate must not be considered in isolation. Deliverables from LANL and from suppliers of supporting systems must be clearly defined.

Committee Observation – The D-Plate requires vacuum and water **resources**, I&C and power defined for the rest of the DTL. Work-a-rounds should be considered. The facility work will likely drive the schedule for this part of the accelerator. Vacuum and water engineer appears to have more work than can be completed in time frame by one person.

Recommendation – Develop **integrated schedule**.

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Committee Observation – **Pump skids** appear to be on the **critical path** for purchasing, delivery, installation, and testing. A plan to use the DTL Tank 2 skid to provide D-Plate water appears to be inconsistent with the water system schedule.

Recommendation – Develop **integrated schedule**.

Committee Observation – There appear to be open questions regarding the **"hand-off"** of the D-Plate system from LANL and ORNL, for instance in areas including assembly and shipping. Who assembles which pieces, where is vacuum leak testing done, how can duplication of effort be minimized?

Recommendation – Assembly and shipping **methodology** need to be carefully considered. Communication between LANL and ORNL mechanical and installation groups needs to take place to resolve these issues at an early stage to avoid un-necessary costs. You might check with recent work done by Phil Mutton at JLAB concerning acceleration of components during shipping.

Committee Observation – It was not clear that the D-Plate has been specified consistently with all the beam measurements that need to be made from a **beam physics perspective**; for instance, no moment spread analyzer is included. Not all **requirements** of D-Plate diagnostics are yet well defined, especially for non-standard equipment like large bore BPMs and slit/collector emittance device. What is required accuracy, sensitivity, resolution for what beam parameters (full current/reduced current). Some accuracy parameters are derived from purely theoretical formulae without real life considerations, for example in the TOF measurements. Numerous accuracy requirements were presented in a hand-waving manner. It appeared that requirements that had been established for permanent linac diagnostics systems were simply attached to D-Plate systems. It is not obvious that the same requirements apply to meet the commissioning goals of the D-Plate as described by Stovall.

Recommendation – Carefully consider again the **full range of measurements and beam modes** for which each D-Plate subsystem is required to perform.

Recommendation – Consider **electrically isolating** the D-Plate beam **absorber** to provide an additional inexpensive beam intensity diagnostic.

Committee Observation – Design of the **emittance slit and energy degrader** were not presented. It was claimed that they would be similar to existing LEDA hardware. However, beam parameters are not exactly the same, therefore it would be desirable at least to provide simplified analysis of thermal load etc. Emittance measurements are likely to be the most important contribution of the D-Plate.

Committee Observation – Thermal analysis of the **beam stop** has received considerable attention and development time, but still there is no confidence that all scenarios are considered: beam mismatch, beam offset etc. There is no direct measure of beam spot size on the beam stop; what happens if the D-Plate system is started up with a reversed quadrupole magnet? The safety margin for the design is not clear.

Recommendation – The D-Plate system, especially the beam stop, would benefit from a **failure mode analysis** effort. Beam stop analysis should consider worst-case beam spot and not just average ideal centerline case. Look at the optics and design for the smallest beam or devise controls to prevent delivery of the worst-case beam if it will burn through the beam stop wall. What mis-steering and mis-focusing scenarios can damage components? What mitigation concepts might avoid that damage?

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Committee Observation – Design of mechanical supports were presented but **mechanical tolerances** were not discussed.

Committee Observation - No **alignment specifications or procedures** were offered and apparently none have been defined for the D-plate. Alignment of individual devices on the D-Plate itself and alignment of the D-Plate relative to DTL Tank 1 should have been considered by this stage of mechanical design. Laser trackers require much more forethought and engineering design to be used effectively with equipment originally designed for optical alignment. This needs a lot of work.

Recommendation – Determine alignment requirements as soon as possible. **Establish specifications and alignment procedures** so that impacts on mechanical design may be addressed at the earliest opportunity.

Committee Observation – The committed was presented a block diagram for the water control systems that will be used throughout the SNS Linac and for the D-Plate. **No hardwire connection between the water systems and the Machine Protection System** was identified on the diagram.

Recommendation – This obvious oversight **must be rectified**.

Committee Observation - It was noted that the **water systems throughout SNS** (not just for D-Plate) are planning to rely on manual valves for flow control. This is especially dangerous for the Linac. Copper structures are very sensitive to water flow velocities. Ranging flow meters will work for a few years and then they will stick due to copper oxide deposits. LANSCE has lost two drift tubes due to water channel erosion and is slowly installing Griswald flow controllers on all systems. These prevent well-intended personnel from open a valve unannounced and possibly ruining expensive Linac copper structures.

Committee Observation – There appeared to be confusion or lack of closure on the **water pressure requirements** for the D-Plate beam stop.

Recommendation – There is no reason the beam stop should drive special water system pressure requirements. **Design beam stop to use normal water system pressures.**

Committee Observation – Calculations of **vacuum load** in the D-Plate system at full power were not presented. Is beam load taken into account? Transient pressure bursts might be important for operation at full power.

Recommendation – Consider whether it might be wise to do **vacuum calculations** to include the loading caused by the beam on the dump. The loading will probably be addressed as "conditioning" as the beam power is increased during the initial operation of the system.

Committee Observation – The D-Plate drawing depicts a **large diameter vacuum connection** from the D-Plate to the Tank 1 interface. The purpose of this was not appreciated by the committee and it was noted that the high conductance connection might increase the possibility that "bad vacuum" from the D-Plate might feed back into the DTL tank. Is it optimal to connect DTL vacuum to the D-Plate chamber (presumably dirty) by a high conductance pipe?

Recommendation – Consider whether a **lower conductance connection** might not be preferred.

Committee Observation – There confusion was expressed as to what materials and design was needed for a **Faraday cup** and there was no specification provided for the **energy degrader**.